CLAIMS

What is claimed is:

1. A low profile splicer system for joining a first optical fiber and a second optical fiber along a common fiber axis by fusion splicing, the system comprising:

   a) a low profile fusion splicing head including a low profile fusion splicing stage comprising:

      (i) a clamping and fiber position adjustment system having holding means for holding said fibers substantially in a horizontal plane and motion means for moving said fibers in three orthogonal dimensions into coaxial, abutting alignment;

      (ii) an imaging optical system having a fiber imaging illuminator and a fiber image detector, said imaging optical system being adapted to acquire optical images of said fibers in a first imaging direction and a second imaging direction, said imaging directions being non-coincident;

      (iii) an electric arc welding system; and

   b) a user interface having an output display and user input controls for activating the splicing system;

   c) electronic control circuitry having:

      (i) imaging electronics that receive the output of said fiber image detector and produce a display signal feeding said output display; and

(ii) fusion control electronics operably connected to activate said electric arc welding system and supply high voltage thereto.

2. A system as recited by claim 1, wherein said first and second imaging directions are substantially mutually orthogonal.

3. A system as recited by claim 1, wherein each of said imaging directions is substantially orthogonal to said common fiber axis.

4. A system as recited by claim 1, wherein said fiber image detector comprises a single imaging device.

5. A system as recited by claim 1, wherein said fiber image detector comprises a CMOS device.

6. A system as recited by claim 1, wherein said fiber imaging illuminator comprises a first light source for said first imaging direction and a second light source for said second imaging direction.

7. A system as recited by claim 6, wherein:

a) light from said first source traverses a first optical path and light from said second source traverses a second optical path, each of said paths being multiply folded;

b) said imaging optical system comprises optical elements located above and below said horizontal plane; and

c) said first and second optical paths lie substantially in a plane perpendicular to said common fiber axis.

8. A system as recited by claim 1, wherein said electronic control circuitry further comprises a profile alignment system in communication with said fiber image detector and said motion means, and said profile alignment system is

adapted to automatically command said motion means to bring said fibers into alignment prior to said fusion.

9. A system as recited by claim 1, wherein:

a) said fusion splicing head further comprises a low profile local injection and detection system including:

(i) a light injector adapted to inject light into said first fiber;

(ii) and a light detector detecting light in said second fiber; and

(iii) wherein said local injection and detection system provides an electronic intensity signal indicative of the fraction of said injected light propagated across the interface between said fibers;

b) said electronic control circuitry further comprises:

(i) a driver energizing said light injector and measurement electronics connected to said light detector receiving and processing said electronic intensity signal to provide a measured intensity signal;

(ii) a servo system operative to drive said motion means to maximize said measured intensity signal, whereby the relative position of said fibers is optimized prior to fusion thereof.

10. A system as recited by claim 9, wherein:

a) said light injector comprises:

(i) an injector cover, at least a portion of which is movable in said horizontal plane, said movable portion having an open position and a closed position, the open position permitting insertion of said first fiber into said injector;

(ii) an injector window having an entry face and a concave, arcuate exit face;

(iii) an injector mandrel having a shape complementary to that of said exit face of said injector window, and being biased to clasp a portion of said first optical fiber in intimate contact between said injector mandrel and said exit face of said injector window, said injector mandrel being reversibly retractable from said exit face in response to motion of said injector cover from the closed position to the open position thereof;

(iv) a light source positioned proximate said entry face of said injector window, whereby light emanating from said source passes through said injector window into said first fiber at said exit face; and

(v) said first fiber entering said injector in an entry direction and emerging from said injector in an exit direction, said entry and exit directions being substantially parallel, and said first fiber traversing a path through said injector substantially in said horizontal plane ; and

b) said light detector comprises:

(i) a detector cover, at least a portion of which is movable in said horizontal plane, said movable portion having an open position and a closed position, the open position permitting insertion of said second fiber into said detector;

(ii) a detector window having a concave, arcuate entry face and an exit face;

(iii) a detector mandrel having a shape complementary to that of said entry face of said detector window, said detector mandrel being biased to clasp a portion of said second optical fiber in intimate contact between said detector mandrel and said entry face of said detector window, and said detector mandrel being reversibly retractable from said entry face in response to motion of said detector cover from the closed position to the open position thereof;

(iv) a light responsive element to detect light emerging from said fiber, said light responsive element being positioned proximate said exit face, whereby light emanating from said fiber at said entry face passes through said detector window into said light responsive element; and

(v) said second fiber entering said detector in an entry direction and emerging from said detector in an exit direction, said entry and exit directions being substantially parallel, and said second fiber traversing a path through said detector in said horizontal plane.

11. A system as recited by claim 10, wherein said movable portions of said injector cover and said detector cover are slidably movable.

12. A system as recited by claim 10, wherein said injector cover and said detector cover are opaque to light of the wavelength emitted by said light injector.

13. A system as recited by claim 1, wherein said light emitted by said light injector is produced by a light emitting diode.

14. A system as recited by claim 1, wherein said light emitted by said light injector is produced by a laser.

15. A system as recited by claim 1, wherein said light emitted by said light injector has a wavelength ranging from about 800 to 900 nm.

16. A system as recited by claim 1, further comprising writeable data storage means adapted to store and transfer data associated with the operation of said splicing system.

17. A system as recited by claim 1, wherein said holding means comprises first and second removable clamp assemblies, each assembly having alignment pins for locating said assemblies in said splicing head.

18. A system as recited by claim 1, wherein said motion means comprises at least one electric motor adapted to drive at least one of said fibers.

19. A system as recited by claim 18, wherein said electric motor gearlessly drives said at least one fiber.

20. A system as recited by claim 18 comprising a first electric motor adapted to drive said first fiber axially and a second electric motor adapted to drive said second fiber axially.

21. A system as recited by claim 1, wherein said motion means comprises at least one piezoelectric actuator.

22. A system as recited by claim 21, wherein said motion means comprises a first transverse piezoelectric actuator adapted to drive one of said fibers in a first transverse direction substantially perpendicular to said common fiber axis; and a second transverse piezoelectric actuator adapted to drive one of said fibers in a second transverse direction substantially perpendicular to said first transverse direction and said common fiber axis.

23. A system as recited by claim 22, wherein said first transverse piezoelectric actuator is adapted to drive said first fiber and said second transverse piezoelectric actuator is adapted to drive said second fiber.

24. A system as recited by claim 22, wherein said first and said second transverse piezoelectric actuators are adapted to drive the same one of said fibers.

25. A system as recited by claim 22, further comprising an axial piezoelectric actuator adapted to drive one of said fibers in said common fiber direction.

26. A system as recited by claim 1, wherein said user input controls comprise control buttons.

27. A system as recited by claim 1, wherein said user input controls comprise a touch screen.

28. A system as recited by claim 1, the components of said system being disposed in a plurality of modules.

29. A system as recited by claim 28, wherein said modules are separable.

30. A system as recited by claim 9, wherein the vertical extent of said system is substantially the same with said injector, detector, and splicing stage in said open and closed positions.

31. A method for joining a first optical fiber and a second optical fiber along a common fiber axis, the method comprising:

a) providing a low profile fusion splicing system, the system comprising:

(i) a low profile fusion splicing head having a fusion splicing stage including a clamping and fiber position adjustment system comprising holding means for holding said fibers substantially in a horizontal plane and motion means for moving said fibers in

three orthogonal dimensions into coaxial, abutting alignment; an imaging optical system having a fiber imaging illuminator and a fiber image detector, said imaging optical system being adapted to acquire optical images of said fibers in a first imaging direction and a second imaging direction, said imaging directions being non-coincident; and an electric arc welding system;

(ii) a user interface having an output display and user input controls for activating the splicing system;

(iii) electronic control circuitry having imaging electronics that receive the output of said fiber image detector and produce a display signal feeding said output display; and fusion control electronics operably connected to activate said electric arc welding system and supply high voltage thereto;

b) preparing said first and second optical fibers by removing coatings present thereon and cleaving the ends of the fibers to form a mating end on each fiber;

c) arranging said first and second optical fibers in said holding means with said mating ends in facing relationship;

d) imaging said fibers prior to said joining;

e) positioning said optical fibers into coaxial, abutting alignment,; and

f) fusing said fibers by electric arc welding.

32. A method as recited by claim 31, wherein said arranging comprises clamping said fibers in V-blocks comprised in said holding means in said fusion head.

33. A method as recited by claim 32, wherein said holding means comprises a first and a second removable clamp assembly.

34. A method as recited by claim 33 wherein: said fibers are mounted in said removable clamp assemblies prior to said preparing of said fibers; said preparing of said fibers is carried out using an auxiliary fiber preparation apparatus; and said arranging comprises placing said removable clamp assemblies bearing said fibers in said fusion splicing system.

35. A method as recited by claim 31, wherein said electronic control circuitry further comprises a profile alignment system in communication with said fiber image detector and said positioning comprises use of said profile alignment system to command said motion means to bring said fibers into alignment.

36. A method as recited by claim 31, wherein:

a) said fusion splicing head further comprises a local injection and detection system including a light injector adapted to inject light into said first fiber and a light detector detecting light in said second fiber, said local injection and detection system providing an electronic intensity signal indicative of the fraction of said injected light propagated across the interface between said fibers;

b) said electronic control circuitry further comprises a driver energizing said light injector and measurement electronics connected to said light detector receiving and processing said electronic intensity signal to provide a measured intensity signal; and a servo system operative to drive said actuators to maximize said measured intensity signal, whereby the position of said fibers is optimized prior to fusion thereof;

c) said method further comprises mounting said first optical fiber in said light injector and said second optical fiber in said light detector; and

d) said positioning comprises use of said servo system to command said motion means to bring said fibers into alignment.

37. A method as recited by claim 31, wherein said positioning comprises translation of said fibers in three mutually orthogonal directions.

38. A method as recited by claim 37, wherein one of said mutually orthogonal directions is substantially coincident with said common fiber axis.

39. A method as recited by claim 37, wherein said positioning comprises translation of said first fiber in a first transverse direction substantially orthogonal to said fiber direction and translation of said second fiber in a second transverse direction substantially orthogonal to said fiber direction and said first transverse direction.

40. A method as recited by claim 31, further comprising inferring the transmission loss of said fiber after said fusing.

41. A method as recited by claim 31, further comprising encasing said fused joint in a heat shrinkable sheath.

42. A method as recited by claim 36, wherein said light injected by said light injector has a wavelength ranging from about 800 to 900 nm.

43. A method as recited by claim 31, further comprising storing and transferring data associated with said joining.